Industrial Technologies Program

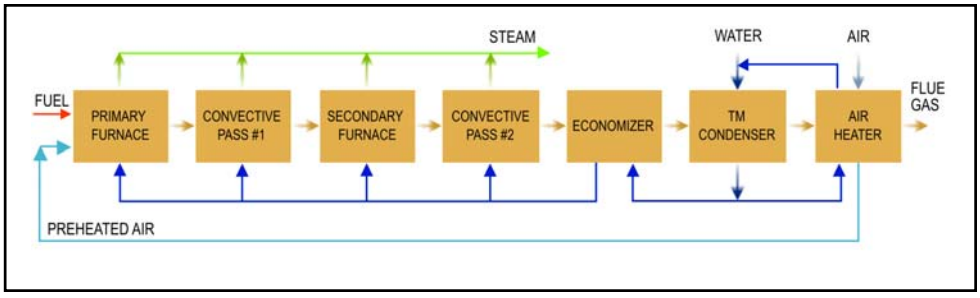
Super Boiler

U.S. industry uses more energy for steam production than for any other single purpose. It costs industry about $18 billion or more annually just to feed the boilers that generate steam, yet industrial steam generation technology has not progressed significantly since the end of the 19th century. An important window of opportunity will open as the aging stock of existing industrial boilers nears retirement. The U.S. manufacturing sector uses more than 33,000 boilers with capacities greater than $10x10^6$ Btu/hr. Of these, over 80% were purchased prior to 1978, with the largest block purchased in the 1960's. About 60% of these boilers are concentrated in just five industries: paper, chemicals, refining, food, and primary metals.

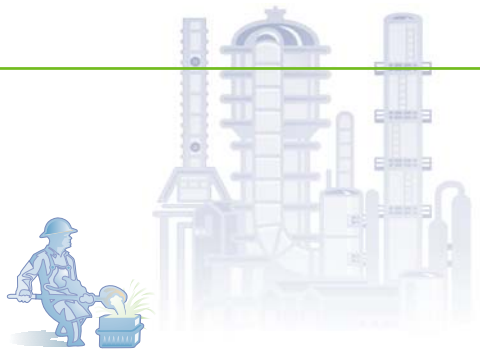
As part of a new Super Boiler program, researchers are working to develop new, breakthrough steam generation technologies that will potentially save U.S. industry over $10 billion annually in operating costs and minimize environmental impacts from steam generation nationwide. The first generation Super Boiler will integrate several novel technologies to achieve extraordinarily high efficiency (>94%) and low emissions (NO_x <5 vppm).

The boiler geometry incorporates a two-stage firetube design that is both compact and highly efficient. Key innovations include a transport membrane (TM) condenser and compact air heater to extract sensible and latent heat from the flue gas for increased energy efficiency; compact convective zones with intensive heat transfer; and a staged/intercooled combustion system for ultra-low emissions.

The First-Generation Super Boiler will be designed and developed for field demonstration under this project. A conceptual diagram of the interconnected boiler system elements is shown below.



This diagram shows Super Boiler innovations such as the transport membrane condenser, convective heat transfer zones, and staged/intercooled combustion. These components of the Super Boiler will dramatically increase energy efficiency and reduce emissions.



Benefits

- *185 trillion Btu/year in energy savings*
- *$724 million/year in fuel cost savings in the industrial packaged boiler market alone*
- *$2.2 billion/year in fuel cost savings with extension to field-erected boilers*
- *Carbon reductions of 2.67 MMTCE*
- *25% capital cost reduction*
- *Compelling economic benefits to accelerate replacement of aging boilers*

Applications

Steam is used in almost every manufacturing industry to provide process heat, electricity, and space heating.

Project Partners

- *Gas Technology Institute*
- *Cleaver-Brooks Division of Aqua-Chem Inc.*
- *GTI Sustaining Membership Program*
- *Pacific Northwest National Laboratory*
- *Southern California Gas Company*

Project Description

Goal: The first Super Boiler project will ascertain whether the individual advanced technologies (TM condenser, intensive heat transfer, staged/intercooled combustion) meet specifications and perform well in a systems environment. The goal is to then successfully integrate several of the unique, advanced combustion concepts into a technically and economically feasible boiler design.

Performance Targets:

Overall Boiler Efficiency	94%
Stack Temperature	< 150°F
NO_X Emissions	< 5 ppm
CO Emissions	< 5 ppm
VOC Emissions	< 1 ppm
Footprint Reduction	50%

Progress and Milestones

- This R&D project was initiated in July 2000.
- An Industry Advisory Group (IAG) was formed in 2001, and drafted a long-term RD&D plan to develop a family of future generation Super Boilers by the year 2020; the plan was submitted to DOE in October 2002.
- In October 2003, the project team began testing a single-stage lab boiler that uses a staged ultra-low-NOx burner and convective pass tubes with internal extended surfaces for intensive heat transfer. NOx emissions for this lab boiler were in the range of 7 ppmv (ref 3% O2) over a 4 to 1 turndown.
- In March 2004, a two-stage furnace design with an interstage convective pass, was put into operation. This boiler is even more compact and has been tested with NOx emissions down to 3 ppmv at low excess air and with no external flue gas recirculation.
- Performance of the novel heat recovery system has been confirmed with fuel-to-steam efficiency of 89% at full load, and design improvements are being implemented to achieve the target efficiency of 94%.
- GTI and Cleaver-Brooks are developing a comprehensive commercialization plan starting with demonstration of a 250-BHP (10 MMBtu/h) prototype in southern California. Engineering design is scheduled to start in September 2004 with testing to begin in May 2005. Follow-on demonstrations are also planned for various other locations across the U.S.

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June 2003